Assessment of the Potential for Cross Contamination of Food Products by Reusable Shopping Bags

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Summary

Most foodborne illnesses are believed to originate in the home. Reuse of bags creates an opportunity for cross contamination of foods. The purpose of this study was to assess the potential for cross contamination of food products from reusable bags used to carry groceries. Reusable bags were collected at random from consumers as they entered grocery stores in California and Arizona. In interviews it was found that reusable bags are seldom if ever washed and often used for multiple purposes. Large numbers of bacteria were found in almost all bags and coliform bacteria in half. *Escherichia coli* were identified in 12% of the bags and a wide range of enteric bacteria, including several opportunistic pathogens. When meat juices were added to bags and stored in the trunks of cars for two hours the number of bacteria increased 10-fold indicating the potential for bacterial growth in the bags. Hand or machine washing was found to reduce the bacteria in bags by >99.9%. These results indicate that reusable bags can play a significant role in the cross contamination of foods if not properly washed on a regular basis. It is recommended that the public needs to be educated about the proper care of reusable bags by printed instructions on the bags or through public service announcements

Introduction

Most foodborne illnesses are believed to originate in food prepared or consumed in the home (van Asselt et al., 2008). Cross contamination of foods during handling is one of the factors leading to this statistic. Cross contamination occurs when disease causing microorganisms are transferred from one food to another. For example raw meat products are often contaminated with foodborne bacteria such as *Salmonella* and *Campylobacter*. While cooking these foods usually destroy these bacteria they may be transferred to other foods, which may be consumed uncooked, or contaminate the hands of consumers and be directly transferred to the mouth resulting in infection. Transfer may occur by surfaces such as cutting boards, kitchen counter tops and by the hands. Reusable bags for transport of groceries from the store to the consumer's home have become popular in recent years. Since these bags are often reused, and used potentially for multiple purposes, the possibility for contamination of food products as well as the consumer's hands exists.

The goal of this project was to assess the potential for reusable bags to cross contaminate foods carried in reusable bags. The project was divided into three phases

- Determine the occurrence of bacteria and bacteria of health concern in reusable shopping bags (phase 1)
- Determine the potential for microbial cross-contamination in reusable shopping bags (phase 2)
- Evaluate and recommend the washing/bleaching procedures necessary to decontaminate reusable shopping bags (phase 3)

Material and Methods

Collection and sampling of bags

Shopping bags were collected from consumers entering grocery stores from the San Francisco Bay area, the greater Los Angeles and Tucson, Arizona. A total of 84 bags were collected (25 Los Angeles, 25, San Francisco and 34 from Tucson) from each location. All but a few bags (4) where woven polypropylene. Individuals were interviewed on bag usage and storage and cleaning

procedures. In addition four new unused reusable bags purchased at local markets and four new plastic disposal bags were also tested.

The bags were sampled using sponge-sticks (3M Corporation, St. Paul, MN) by swabbing the entire inside of the bag. Three to four ml of fluid was extracted from the sponge-stick by squeezing it from the sponge in a plastic bag.

Bacterial assays and identifications

Total heterotrophic plate count bacteria were determined by dilution of samples in buffered peptone water and spread plating on R2A media (Difco, Sparks, MD). This media is designed to enhance the recovery of stressed bacteria. The plates were incubated for five days at room temperature and colonies counted.

Coliform and *Escherichia coli* bacteria were identified by placing one ml of the sponge-stick extract into 99 ml of Colilert media (IDDEX, Westbrook, ME) and placement in a Quantray system or Simplates (IDDEX, Westbrook, ME) and inoculation overnight at 37 ^{o}C. Coliform and *E. coli* numbers were then determined using a most probable number (MPN) table provided by the manufacturer. Identification was conducted by diluting positive samples on MacConkley's agar (Difco) and selecting colonies of different morphology and subculturing on Trypticase Soy Agar (Difco). The bacteria were then identified using APIE20 strips (Biomerieux, Durham, NC).

Salmonella isolation was attempted by inoculating one ml of sponge-stick extract into 9 ml of buffered peptone water and incubation for 24 hours at 35^{o}C and then subcultured into Rappaport-Vassiliads media (Difco) and at 35 ^{o}C for 24-48 hours. Positive samples were then subcultured on both Hektoen and XLD agar (Difco) at 35 ^{o}C for 24 to 48 hrs.

Listeria isolation was attempted by inoculating one ml of sponge-stick extract into 9 ml of UVM media and incubated at 30 ^{o}C for 24-48 hrs. This was then passed in Frasier's broth and incubated at 35 ^{o}C for 24-48 hrs. The broth was then streaked onto L mono plates (Bio-Rad, Chicago, IL) for isolation of *Listeria*.

Assessment of bacteria growth in stored bags

To assess the potential for bacteria growth in stored reusable bags, raw chicken and beef were hand wiped with sterile gloves and the resulting juices collected in a beaker. The solution was then spiked with approximately 10^6 *Salmonella typhimurium* from an overnight culture. This was then added to 8 by 7 cm swatches cut from reusable grocery bags and placed in a Ziploc bag. Half of the swatches were processed immediately by cutting into one cm^2 sections and placement in 10 ml of buffered peptone water, and placement in a stomacher bag, and

processed for 15 minutes in a stomacher. The sample was then diluted and assayed on XLD media. The other set of samples was placed in the trunk of a car for two hours during the mid afternoon. To determine the potential for growth of bacteria in the meat juices, another set of swatches was processed, but *Salmonella* was not added. This experiment was repeated twice on two different days.

Effect of washing on reduction of bacteria on reusable bags

This phase of the study designed to assess proper washing conditions to eliminate bacteria from reusable shopping bags. Reusable washable woven polypropylene bags were purchased at a local grocery store and spiked with *S. typhimurium* suspended in meat juices as described in the previous section. The bottom of the bag and sides were spiked by adding 5 ml in 0.1 ml drops. The bags were then allowed to air dry for 30 minutes. One bag was processed immediately after drying by swabbing with a sponge-stick and processed as described previously. The sponge extract was assayed directly on XLD media at 37 ^{o}C for 24 hours and black colonies counted. An additional three bags were washed with a 30 minute wash cycle with a standard household detergent (61.1) without bleach (Tide, Procter and Gamble, Cincinnati, OH). The bags were then placed in a dryer at 55 ^{o}C for 20 minutes. The bags were then sampled using a sponge-stick.

To assess the effect of hand washing another set of bags treated in the same manner were hand washed and rinsed in a five gallon bucket containing water using rubber gloves and allowed to dry overnight before sampling. The bags were placed in the wash water containing detergent (Tide, Procter and Gamble, Cincinnati) (11.3 g in 10 L) and allowed to soak for 30 minutes before hand washing. The experiment was repeated in duplicate.

Results

Profile of bag use

Interviews indicated that half the bags were used more one day per week (Figure 1) and that most were used only for groceries (Figure 2). Other uses including non grocery shopping, storage of snacks and transport of books (Figure 3).

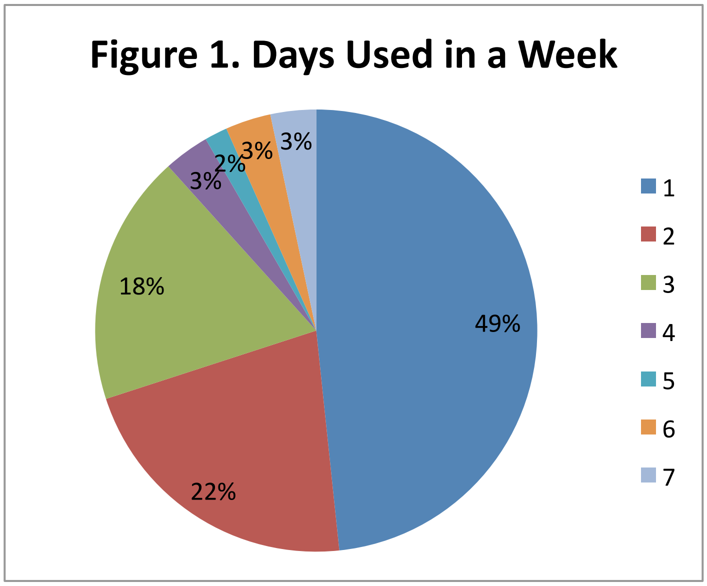


Figure 1. Days Used in a Week
49%
22%
18%
3%
2%
3%
3%
1
2
3
4
5
6
7

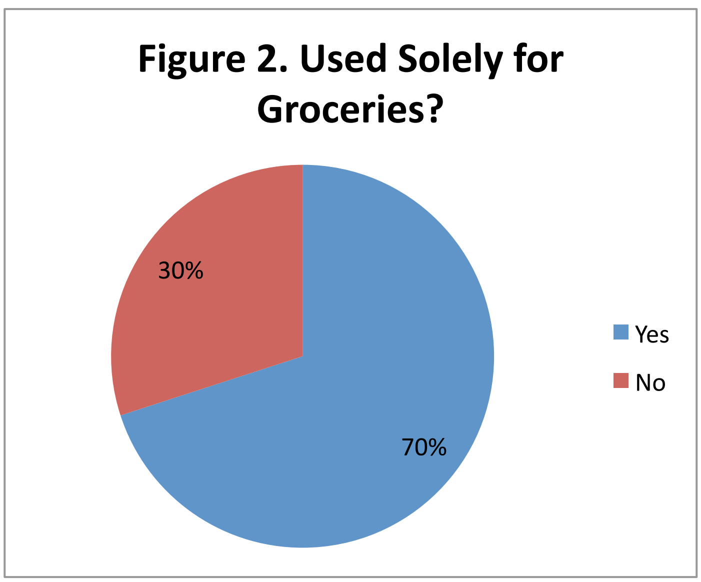
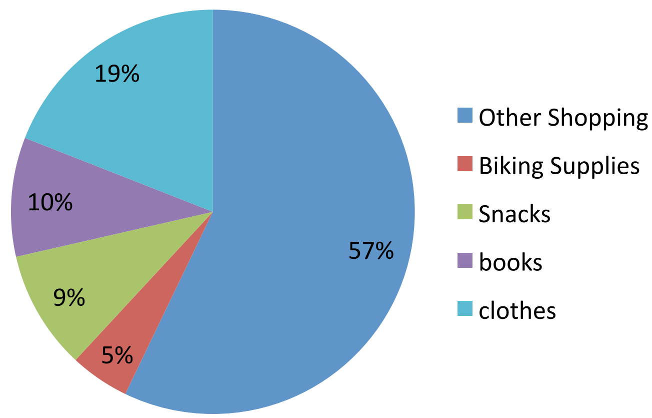


Figure 2. Used Solely for Groceries?
30%
70%
Yes
No

Figure 3. Other Uses



Few people separated the vegetables and raw meat into different bags (Figure 4). Most bags were transported in cars and stored at home (Figure 5) or in the car between uses (Figure 6).

Figure 4. Seperate Bags for Meats & Vegetables

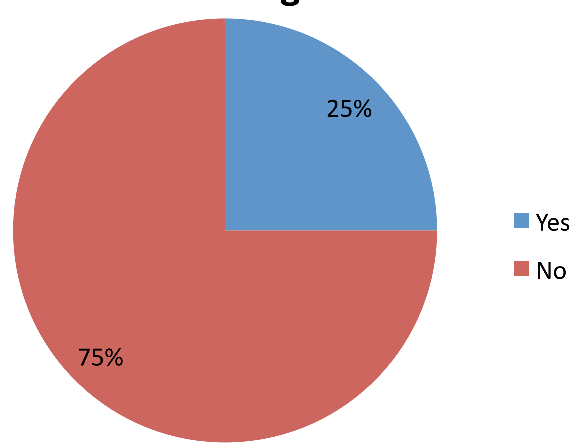
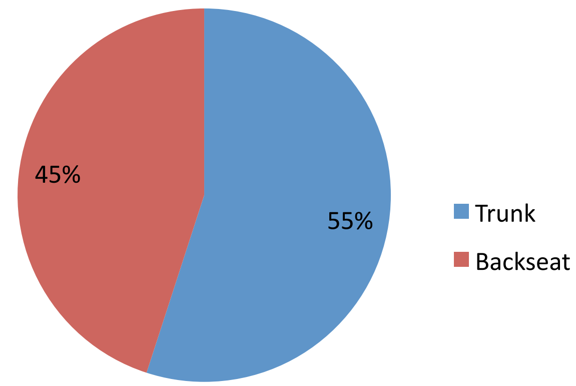
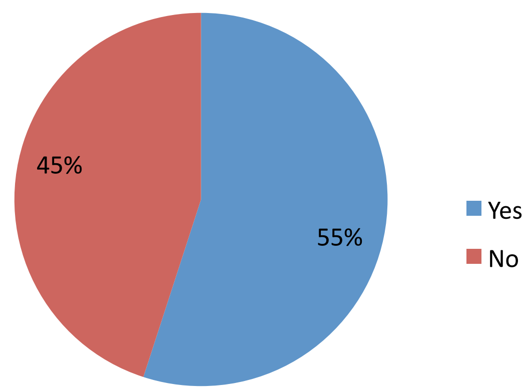


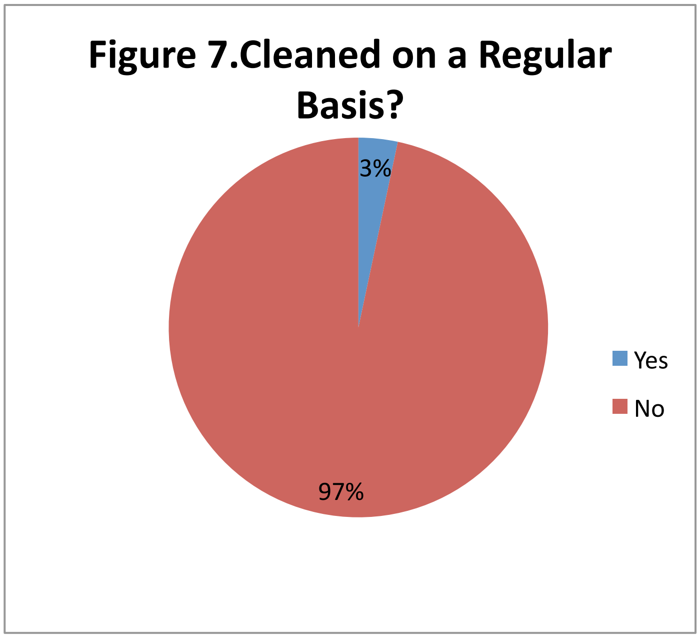
Figure 5. Transport in Car



Bags were almost never cleaned and washed (Figure 7). Only 3% of persons reported ever cleaning reusable bags.

Figure 6. Storage at home





Bacteria detected in bags

No bacteria were detected in new cloth reusable bags and in new plastic bags obtained from grocery stores (Table 1). However, large numbers of bacteria were detected in reusable bags collected from consumers. HPC bacteria ranged from 45 to greater than 800,000 per bag. Only one bag was negative for HPC bacteria (< 30 colony forming units). Coliform bacteria were detected in 51% of the bags tested (Figure 8). In bags containing coliform bacteria the numbers detected ranged from 3 to 3,330 per bag. HPC bacteria averaged 22,600 and coliform bacteria 576 (Figure 9). Greater numbers of bacteria and coliform bacteria where found in reusable bags collected in California than Arizona. This may be due to the drier climate in Arizona, which could affect bacteria survival. The greatest numbers of HPC and coliform bacteria were found in the Los Angeles area.

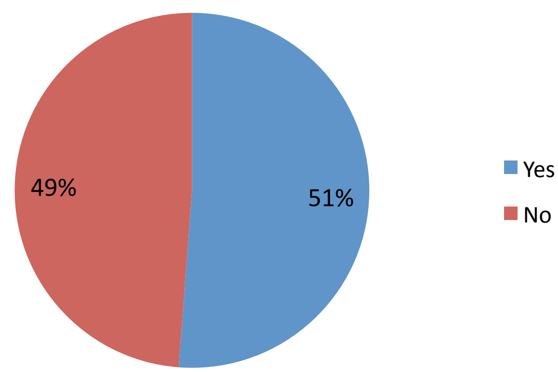
Table 1. Coliform and HPC bacteria in unused reusable and plastic bags

Bag type	HPC* (log_{10})	Coliforms* (log_{10})
Reusable (1)	< 1.48*	< 1.48
Reusable (2)	< 1.48	< 1.48
Reusable (3)	< 1.48	< 1.48
Reusable (4)	< 1.48	< 1.48
Reusable (5)	< 1.48	< 1.48
Plastic (1)	< 1.48	< 1.48

Plastic (2)	**< 1.48**	**< 1.48**
Plastic (3)	**< 1.48**	**< 1.48**
Plastic (4)	**< 1.48**	**< 1.48**

*less than 30 colony forming units log transformed

Figure 8. Presence of Coliform Bacteria



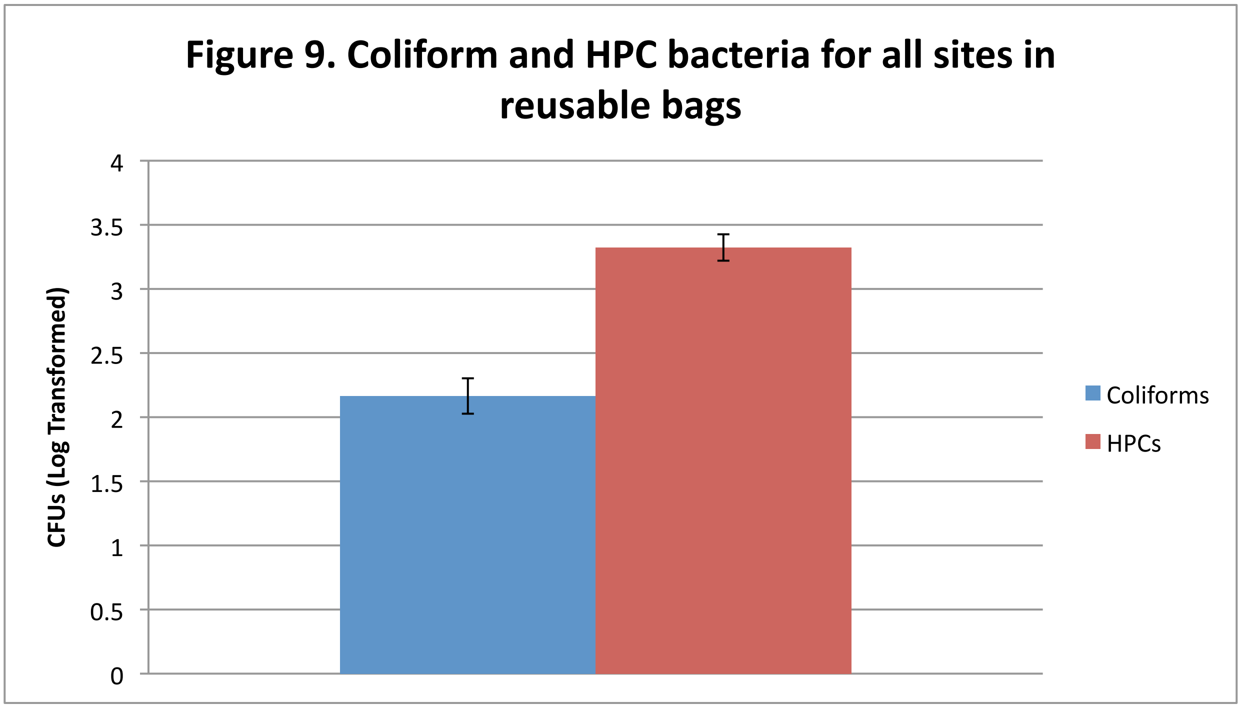


Figure 9. Coliform and HPC bacteria for all sites in reusable bags
CFUs (Log Transformed)
4
3.5
3
2.5
2
1.5
1
0.5
0
Coliforms
HPCs

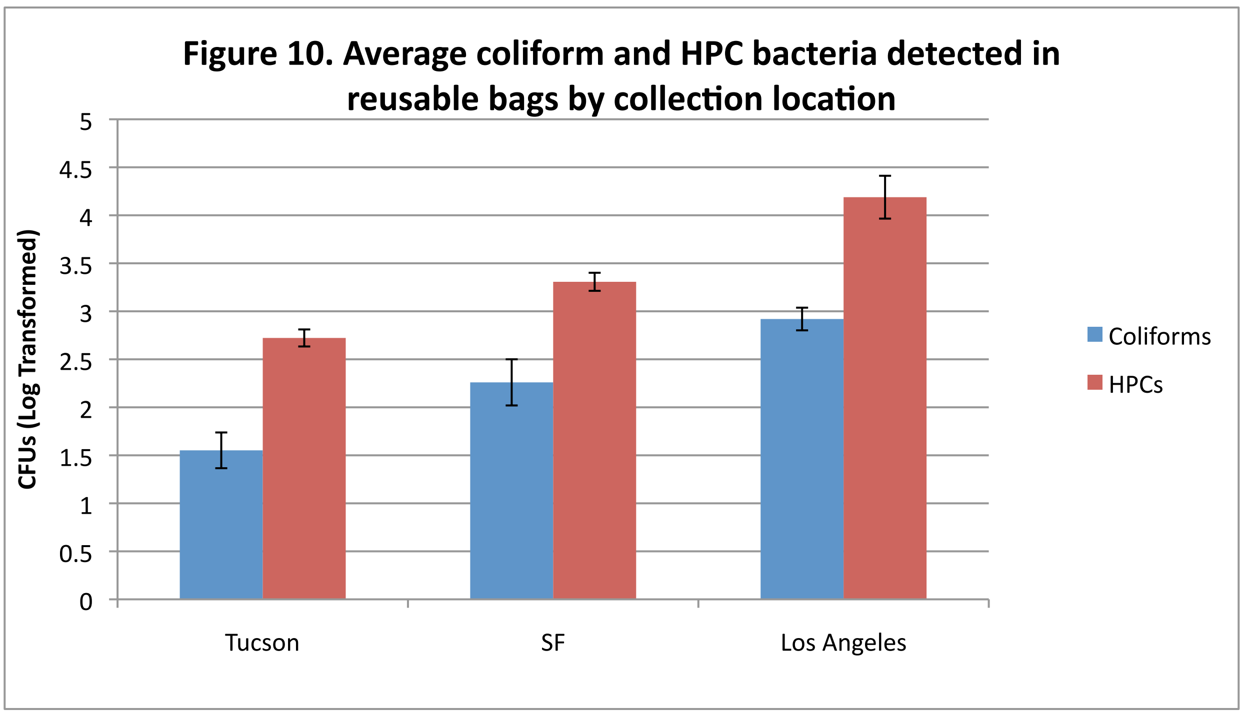


Figure 10. Average coliform and HPC bacteria detected in reusable bags by collection location
CFUs (Log Transformed)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Tucson
SF
Los Angeles
Coliforms
HPCs

A wide variety of coliform bacteria were detected in the bags including *Escherichia coli*. E. coli was identified in seven bags (12% of bags tested). One bag was from Tucson, AZ and the other positives were from the Los Angeles area. Many of the bacteria isolated are capable of causing opportunistic infections in humans.

Table 2. Identity of coliform bacteria detected in reusable bags

Type of Coliform	Number of bags detected
Leclercia Adecarboxylata	1
Enterobacter aerogenes	1
Enterobacter cloacae	2
Enterobacter sakazakii	1
Escherichia vulneris	4
Escherichia coli	7
Klebsiella pneumoniae ssp pneumoniae	5
Klebsiella pneumoniae	1
Pantoea spp 3	4
Serratia ficaria	8
Serratia (ruidae or plymuthica)	1

Assessment of bacterial growth in stored bags

Bacteria in bags to which meat juices were added did grow within two hours of storage. Within this time the number of bacteria increased 10-fold when the temperature was 47 ^{o}C inside the trunk (Table 3). When the temperature was 53 ^{o}C there was a decrease in the number of viable bacteria. The warm temperatures and presence of food in the bags can encourage rapid growth of bacteria.

Table 3. Effect of Car Trunk Storage on the Growth of Bacteria in Reusable Bags (HPC)

Trial	Trunk Temperature (^{o}C)	Colony forming units (CFU)	
		Before	After
1	47	7.11 +/- 0.026	8.19 +/- 0.105
2	53	7.17 +/- 0.025	6.25 +/- 0.088

*Colony forming units (Log Transformed)

Effect of washing on reduction of bacteria on reusable bags

Machine or hand washing even without the presence of bleach was effective in reducing coliform and other bacteria in the bags to levels below detection.

Table 4. Effect of Washing on Bacterial Reduction in Reusable Cloth Bags: Without Bleach

Wash Method	Before*		After*	
	HPC	*Salmonella*	HPC	*Salmonella*
Machine	5.33	5.89	<10	<10
Hand	5.48	5.47	<10	<10

***Colony forming units (Log Transformed)**

Table 5. Effect of Washing on Bacterial Reduction in Reusable Cloth Bags: With Bleach

Wash Method	Before*		After*	
	HPC	*Salmonella*	HPC	*Salmonella*
Machine	4.95	4.66	<10	<10
Hand	4.58	4.79	<10	<10

***Colony forming units (Log Transformed)**

Discussion

It is estimated that there are about 76,000,000 cases of foodborne illness in the United States every year (Buzby and Roberts, 2009). Most of these illnesses originate in the home from improper cooking or handling of foods (van Asselt et al., 2008). Reusable bags if not properly washed between uses, create the potential for cross contamination of foods. This potential exists when raw meat products and foods traditionally eaten uncooked (fruits and vegetables) are carried in the same bags, either together or between uses. This risk can be increased by the growth of bacteria in the bags. The results of this study indicate that large numbers of bacteria occur in reusable bags and are capable of increasing 10-fold in a trunk within a two hours period of time. Slightly more than half of the bags contained coliform bacteria, indicating contamination by raw meats or other uncooked food products. The indicator bacterium E. coli, used to indicate fecal contamination, was detected in 12% of the bags. The presence of these bacteria demonstrates reusable bags do get contaminated by enteric organisms and a risk from food borne pathogens does exist. Attempts to isolate *Salmonella* and *Listeria* bacteria from the

bags were not successful in this study, but this may only represent the limited number of samples that were collected.

Greater numbers of bacteria were present in bags in California than in Arizona. A similar study in Canada also found fewer numbers of total bacteria and coliform bacteria in reusable bags (Summerbell, 2009) than were found in this study. The lower numbers of bacteria found in bags in the Canadian study may represent some differences in methods or that the warmer temperatures in California and Arizona encourage growth of the bacteria in the bags. The greater numbers of bacteria in the bags in California vs. Arizona may reflect the higher relative humidity in California.

Contamination of raw meat products with *Salmonella*, *Campylobacter* and *E. coli* is common. Studies have shown that children are at increased risk of both *Salmonella* and *Camplyobacter* infections if they ride in a shopping cart carrying meat products and eating fruits and vegetables prepared in the home (Jones et al., 2006; Fullterton et al., 2007). This suggests that proper handling of raw food products during shopping and transport to the home is a route of exposure for the transmission of these pathogens. Packaged meats can leak during transport and contaminate the bag. In addition, pathogenic bacteria can also occur on the outside of the packaged meats (Harrison et al., 2001). The common use of bags for other purposes than carrying groceries is also a potential concern. Transporting gym clothes or other clothing may result in cross contamination of bacteria such as MRSA (methicilin resistant *Staphylococcus aureus*).

Cross contamination problems associated with reusable bags for carrying groceries has been recognized by health departments (Minnesota Dept. of Health, 2007; Health Canada, 2010), and they have made recommendations about proper handling and cleaning. In this study it was demonstrated that hand and machine washing were able to reduce the bacteria in the bags below detection. Unfortunately, almost no one interviewed ever washed their reusable bags. Public unawareness of the potential risks seems almost universal. Thus, a sudden or significant increase in use of reusable bags without a major public education campaign on how to reduce the risk of cross contamination would create the risk of significant adverse public health impacts. Approaches such as printed instructions on reusable bags that they be cleaned between uses or the need to separate raw foods from other food products, public service announcements, and health advisories are recommended.

Conclusions and Recommendations

- Consumers almost never wash reusable bags
- Large numbers of bacteria were found in every reusable bag, but none in new bags or plastic bags
- Coliform bacteria including *E. coli* were found in half of the bags tested
- Bacteria were capable of growth when stored in the trunks of cars
- A potential significant risk of bacterial cross contamination exists from using reusable bags to carry groceries
- Hand or machine washing reduced the numbers of bacteria in reusable bags by >99.9%
- Requiring printed instructions on reusable bags that they be washed between uses or the need to separate raw foods from other food products

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